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1 539 315
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(54) CERMET COMPOSITION AND STRAIN GAUGE EMPLOYING THE SAME

(71) We, GOULD INC., a corporation organised and existing under the laws of the State of Delaware, United States of America, of 540 East 105th Street, Cleveland, Ohio 44108, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a cermet composition and to a strain gauge employing a thin film of the said composition.

Strain gauges are employed as movement-electric signal transducers in devices for measuring, inter alia, force, pressure and flexure. Although metals (e.g., chromium) were primarily relied upon at first, semiconductor materials offer certain advantages thereover, such as a greater gauge factor and smaller size. The temperature characteristics of semiconductors have made them not completely satisfactory, however, for precision strain gauge applications.

In a frequently encountered manner of use, the strain gauge is electrically arranged as a bridge (e.g. Wheatstone bridge), and it is important that a positive thermal sensitivity shift (TSS) be maintained. Moreover, it is desirable to be able to control the temperature coefficient of resistance (TCR) of the gauge material within a narrow range.

According to the present invention, there is provided a cermet for use as an electric current conducting element consisting of, by weight, 65%—70% chromium, 18%—32% silicon monoxide, and 3%—12% nickel.

Also, according to the present invention, there is provided a strain gauge comprising an electrically conductive substrate; an insulating layer on said substrate; and an electric current conducting film on the insulating layer consisting of 65%—70% by weight of chromium, 18%—32% by weight of silicon monoxide and 3%—12% by weight of nickel.

The film can be deposited by vacuum evaporation. After initial deposition, vacuum annealing is desirable and, if a more positive TCR and TSS is required, the annealing can be repeated at a higher temperature.

The drawing shows a sectional, elevational view of a strain gauge made in accordance with the invention.

The strain gauge includes a substrate 11 of a heat-treated stainless steel, for example, on to a major surface of which there is evaporation deposited an insulating layer 12 of silicon monoxide (SiO). Next, an electrical current conducting film 13, having the composition described herein, is vacuum deposited on to the SiO layer. Lead pads 14 of chromium for completing electrical connection to the film 13 are also vacuum deposited. Finally, the entire assembly is vacuum annealed to provide a strain gauge having the desired temperature coefficient of resistance (TCR) and a positive thermal sensitivity shift (TSS).

The sensitivity of a strain gauge, which is measured as the output voltage obtained for a given driving voltage on stressing of the gauge, can be expected to change with a change of temperature of the gauge. The compensating circuit associated with a strain gauge can readily counteract any positive (increasing) changes or shifts in sensitivity resulting from temperature variations, but it is difficult to accomplish linearly for negative shifts. Accordingly, it is important that any material contemplated for use as a strain gauge has a positive sensitivity shift on temperature increase to be practically useful.

The strain gauge composition is an alloy of a ceramic material and metal which is

referred to by the term "cermet". Specifically, best results have been obtained to date with a deposited film having the following composition, by weight : 65% Cr, 25% SiO and 10% Ni.

We have also found that a strain gauge having a TCR controllable within a narrow range (−20 PPM/°C. to +20 PPM/°C.) and a positive TSS is obtained with a cermet having the following composition range by weight: 65%—70% Cr; 18%—32% SiO; 3%—12% Ni.

It had been considered that a two-component cermet of chromium and silicon monoxide might have the desired properties for general use as a strain gauge. However, it was found that although a strain gauge bridge made of Cr/SiO in the ratio of 2.5/1 had a positive TCR and positive TSS, the TCR was much too positive for use where a low TCR was required.

It was discovered, however, that by adding nickel to the Cr/SiO material, the TCR could be controllably reduced (made less positive) without driving the TSS negative.

After deposition and prior to annealing, strain gauges made of the three-component alloy described herein or merely of Cr/SiO, have a negative TCR and a negative TSS. During annealing (typically at 805°F.) the two materials react differently. For example, the Cr/SiO formula gauges on annealing experience a positive increase of the TCR, while the TSS either remains the same or decreases (i.e., becomes even more negative). The three-component strain gauge embodying this invention, on the other hand, experiences a positive change of both the TCR and TSS. It is this characteristic of the positively moving TCR and TSS on annealing that provides the desirable capability of controlling the TCR closely without rendering the strain gauge unusable as a result of a negative TSS.

If after vacuum annealing at 805°F. the TCR is found to be insufficiently positive, further annealing at temperatures up to 950°F. will provide a more positive TCR and more positive TSS. In contradistinction, the two-component resistance material (Cr/SiO) on annealing at the higher temperature shows an increase in the TCR, but in most cases also produces a negative movement of the TSS.

WHAT WE CLAIM IS:—

1. A cermet for use as an electric current conducting element consisting of, by weight, 65%—70% chromium, 18%—32% silicon monoxide, and 3%—12% nickel.

2. A cermet according to claim 1, wherein the composition is substantially 65% chromium, 25% silicon monoxide and 10% nickel.

3. A strain gauge comprising an electrically conductive substrate; an insulating layer on said substrate; and an electric current conducting film on the insulating layer consisting of 65%—70% by weight of chromium, 18%—32% by weight of silicon monoxide and 3%—12% by weight of nickel.

4. A strain gauge according to claim 3, in which the substrate consists of stainless steel.

5. A strain gauge according to claim 3, in which the insulating layer consists of silicon monoxide.

6. A strain gauge according to claim 3, in which the substrate is constructed of a stainless steel and the insulating layer consists of silicon monoxide.

7. A strain gauge according to any of claims 3 to 6, in which the insulating layer and the electric current conducting element are evaporation deposited films.

8. A method of making a strain gauge according to claim 3, wherein the said film is deposited on the insulating layer and the deposited film is vacuum annealed to increase the temperature coefficient of resistance.

9. A method according to claim 8, in which the annealing is accomplished by heating the film and insulating layer to at least 805°F.

10. A method according to claim 9, in which the substrate, film and insulating layer are subjected to further annealing at a temperature higher than 805°F.

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1 539315 COMPLETE SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale.